LIU & ASSOCIATES, INC.

Geotechnical Engineering | Engineering Geology | Earth Science

August 11, 2014

Mr. Lucas Kragt
KLN Construction, Inc.
P. O. Box 760
Edmonds, WA 98020

Dear Mr. Kragt:

Subject: Onsite Stormwater Disposal
Bridle Trails
46xx – 116th Avenue NE
Bellevue, Washington
L&A Job No. 14-070

INTRODUCTION

We have completed a geotechnical investigation on onsite stormwater disposal for the proposed subject development project, located at the above address in Bellevue, Washington. We understand that the proposed development is to plat the project site into 35 single-family residential building lots with supporting infrastructure. We also understand that onsite stormwater disposal by infiltration is being considered for the subject project.

The purpose of this investigation is to explore and characterize the subsurface conditions in drainage tracts, evaluate feasibility of onsite stormwater disposal by infiltration, and provide geotechnical recommendations for onsite stormwater disposal. Presented in this report are our findings, conclusion, and recommendations.

19213 Kenlake Place NE · Kenmore, Washington 98028
Phone (425) 483-9134 · Fax (425) 486-2746

SITE CONDITIONS

Surface Condition

The general location of the project site is shown on Plate 1 – Vicinity Map. The site is situated on a moderately-steep, westerly-declining hillside. As shown on Plate 2 – Site and Exploration Location Plan, the site is flagstone-shaped land elongated in the east-west direction and with a handle at its southwest corner. It is bounded by 116th Avenue NE to the west, and adjoined by Bridle Trails State Park to the east and residential development to the north and south.

The terrain within the project site generally slopes down gently to moderately-steeply from the east down towards the west. The site has been graded into level benches on which barns, fenced corrals, and buildings and sheds are located, between moderately steep slopes, gravel roads and trails. The slopes in between the benches are mostly dotted with tall mature trees and covered by lawn grass.

Geologic Setting

The Geologic Map of King County, Washington, by Derek B. Booth, Kathy A. Troost and Aaron P. Wisher (2007) was referenced for the geologic and soil conditions at the property. According to this publication, the surficial soil units at and in the vicinity of the site are mapped as Vashon Till (Q_{vt}) deposits underlain by Advance Outwash (Q_{va}) deposits.

The geology of the Puget Sound Lowland has been modified by the advance and retreat of several glaciers in the past one million years and the subsequent deposits and erosion. The last glacier advanced to the Puget Sound Lowland is referred to as the Vashon Stade of the Fraser Glaciation, which occurred during the later stages of the Pleistocene Epoch and retreated from the region some 12,500 years ago.

The deposits of the Vashon till soil unit (Q_{vt}) were plowed directly under glacial ice during the most recent glacial period as the glacier advanced over an eroded, irregular surface of older formations and sediments. This soil unit is composed of a mixture of unsorted clay, silt, sand, gravel, and scattered cobbles and boulders. The Vashon till soil over the top two to three feet is normally weathered to a medium-dense state, and is moderately permeable and compressible. The underlying fresh till soil, commonly referred to as "hard pan", is very dense and weakly cemented. The fresh till soil possesses a compressive strength comparable to that of low-grade concrete and can remain stable on steep natural slopes or man-make cuts for a long period. The fresh till deposits are practically impervious to stormwater infiltration and can provide excellent foundation support with little or no settlement.

The advance outwash soil unit (Q_{va}), normally underlying the Vashon till soil unit, is composed of stratified sand and gravel with very minor amount of silt and clay, deposited by the meltwater of advancing glacial ice of the last glacier. Due to their generally granular composition, the advance outwash deposits are of moderately high permeability and drains fairly well. The advance outwash deposits had been glacially overridden and

are generally dense to very-dense in their natural, undisturbed state, except the top 2 to 3 feet of soils exposed on slopes which are normally weathered to a loose to medium-dense state. The underlying fresh advance outwash deposits can stand in steep cuts or natural slopes for extended period when undisturbed and properly drained. Where exposed on slopes devoid of vegetation cover and subject to storm runoff or groundwater seepage, the advance outwash deposits can be gradually eroded and may slough and redeposit to a flatter inclination. The fresh advance outwash deposits are also quite stable and capable of providing very good foundation support with little settlement.

Soil Condition

Subsurface conditions of the two storm tracts in the southwest quadrant and immediately south of the SEPA tract in the northeast quadrant of the site were explored with test borings. A geotechnical engineer from our office was present during subsurface exploration, examined the soil and geologic conditions encountered, and completed logs of test pits. The locations of the test borings are shown on Plate 2 – Site and Exploration Location Plan. The test borings were drilled on July 15, 2014, with a tract-mounted drill rig, owned and operated by Davies Drilling of Seattle, Washington.

Soil samples obtained from each soil layer in the test pits were visually classified in general accordance with United Soil Classification System, a copy of which is presented on Plate 3. Detailed descriptions of soils encountered during site exploration are presented in test pit logs on Plates 4 through 6.

Standard Penetration Tests were conducted, in accordance with ASTM D-1586, in the bore holes using a standard split-spoon sampler of 2-inch outside diameter, driven with a 140-pound hammer that was raised and released for a 30-inch free fall. The number of blows required to advance the sampler a given distance is an indication of the density for granular soils or the consistency of cohesive soils. The sampler was advanced 18 inches and the total number of blows for the last 12 inches was recorded on the boring logs as N-values of the Standard Penetration Tests.

All three test borings encountered an advance outwash soil unit with its surface at about 4.0 to 9.5 feet below existing ground surface. The advance outwash deposits are composed of brown to brown-gray to gray, medium-dense to dense, fine to medium sand. Overlying the advance outwash soil unit is a layer or layers of weathered soil of loose to medium-dense, silty fine sand, with peat bedding and wood chips locally. A Lawton Clay soil unit of gray, clayey silt, was encountered at 15.5 feet, underlying the advance outwash deposit in Test Boring B-2.

Groundwater Condition

Groundwater table was encountered in all three test borings at depths from 14.5 to 16.5 feet. This groundwater is perched on the Lawton clay soil unit of extremely low permeability underlying the advance outwash soil unit. The level of the groundwater table would fluctuate seasonally, depending on precipitation, surface runoff, ground vegetation cover, site utilization, and other factors. A groundwater monitoring well was installed in each test bore hole with a PVC stand pipe fit with a 5-foot piezometer tip

inserted in drilled holes. The annular space in the bore holes was then packed with commercial silica sand and sealed with bentonite pallets. The wells were then capped with a well monument secured with a padlock. The monitoring wells will be used to determined winter high groundwater table which will used in consideration of design of infiltration trenches or galleries.

ONSITE STORMWATER DISPOSAL

General

All three test borings encountered advance outwash deposits. Soil samples from the targeted advance outwash sand deposits were obtained for soil particle size distribution test in the laboratory. Feasibility of onsite stormwater disposal was evaluated and infiltration rates were determined based on the test results. The analysis on the test results presented below indicates that the advance outwash sand deposits will be able to support onsite stormwater disposal by infiltration in areas where the test borings were located.

Particle Size Distribution Tests and Estimated Infiltration Rates

Four soil samples were obtained from the advance outwash sand deposits in the test borings and taken to HWA laboratory for Soil Particle Size Distribution tests. These soil samples are listed in the table below and their test reports are presented on Plates A-1 through A-3 in the attached appendix.

LIST OF SOIL SAMPLES

Sample No.	Test Pit No.	Depth feet	Soil Description
1	B-1	7.5 – 9.0	Olive-brown, poorly-graded SAND with silt
2	B-2	7.5 – 9.0	Olive-gray, silty SAND
3	B-2	10.0 – 11.5	Olive-gray, well-graded SAND with silt
4	B-3	7.5 – 9.0	Dark brown, silty SAND

The percentages of clay, silt and sand/gravel of the soil samples determined from the particle size distribution tests are summarized on Plate A-3. Based on these percentages the soil samples were classified according to the USDA (U.S. Department of Agriculture) Texture Triangle chart, a copy of which is shown on Plate A-4 in the attached Appendix. The classifications of soil samples are presented in the table below.

USDA TEXTURE TRIANGLE CLASSIFICATION OF SOIL SAMPLES

Sample No.	Percentage Clay	Percentage Silt	Percentage Sand/Gravel	USDA Texture Triangle Classification
1	2.2	6.5	91.3	Sand
2	5.6	7.6	86.8	Sand
3	5.3	5.7	89.0	Sand
4	4.6	17.4	78.0	Loamy Sand

Volume III, Section 3.3.6, Article 3 - Soil Grain Size Analysis Method, of the Stormwater Management Manual for Western Washington, 2012 Edition, published by Washington State Department of Ecology, is used to determine estimated design infiltration rates of the target soil deposits. This method uses D_{10} , D_{60}, D_{90}, and f_{fines} in

calculating the saturated infiltration rate (conductivity), K_{sat} in cm/sec; where D_{10} , D_{60}, D_{90} are the size in millimeters of soil particles of 10%, 60%, and 90%, respectively, passing by weight, and f_{fines} is the fraction of the fines passing the No. 200 sieve by weight. The values of D_{10} , D_{60}, D_{90}, and f_{fines} are shown or obtained from test results on Plates A-1 through A-3, and the determination of K_{sat} for the four soil samples are shown in the table below.

ESTIMATED INITIAL INFILTRATION RATES, K_{sat}

Sample No.	Test Boring No.	D_{10} Size	D_{60} Size	D_{90} Size	f_{fines}	[a] K_{sat} cm/sec	K_{sat} in/hour
1	1	0.0866	0.310	0.42	0.087	0.0265	37.9
2	2	0.0139	0.305	0.505	0.132	0.0151	21.6
3	2	0.0460	0.310	0.51	0.110	0.0193	27.6
4	3	0.0100	0.27	0.59	0.220	0.00972	13.9

[a] $\log_{10}(K_{sat}) = -1.57 + 1.90(D_{10}) + 0.015(D_{60}) - 0.013(D_{90}) - 2.08(f_{fines})$

Recommended Design Infiltration Rate

We recommend the design infiltration rate for infiltration trenches or galleries to be used for onsite stormwater disposal for the subject project be determined by taking the lowest value from the table above and apply a factor safety of 4 to it. Therefore, our recommended design infiltration rate in the advance outwash sand deposits would be 3.5 iph (inches per hour).

INFILTRATION TRENCHES/GALLERIES

General

It is our opinion that based on the soil conditions encountered by the test borings and the results of particle size distribution tests on the soil samples, the targeted advance outwash sand deposits underlying the site at shallow depth are capable of supporting infiltration trenches or galleries to be used for onsite stormwater disposal. Infiltration trenches/galleries should be set back at least 5 feet from property lines, 10 feet from adjacent building footing foundations or utility trenches, and 25 feet from the top of slopes of 40% grade or more. Also, the bottom of infiltration trenches or galleries should be at least one foot lower than adjacent building footing foundations or utility trenches.

Infiltration Trench/Gallery Construction

The trenches should be cut at least 6 inches into the advance outwash deposits of clean, fine to medium sand. To reach this target soil stratum the trenches would have to be excavated to about 5.0 to 10.0 feet deep or more, depending on the locations of the infiltration trenches. The condition of the soil unit at bottom of trenches should be verified by a geotechnical engineer. The stability of the trench cut banks should also be verified by a geotechnical engineer during excavation.

The trenches should be at least 24 inches wide. The side walls of the trenches should be lined with a layer of non-woven filter fabric, such as MIRAFI 140NS. The trenches are then filled with clean washed 3/4 to 1-1/2 inch gravel or crushed rock to within about 12 inches of the finish grade. The dispersion pipes should be constructed of 4-inch rigid

PVC pipes and laid level in the gravel or crushed rock filled trenches at about 24 inches below the top of trenches. The top of the gravel or crushed rock fill should also be covered with the filter fabric liner. The remaining trenches should then be backfilled with compacted onsite clean sandy soils. The gravel or crushed rock fill should be placed in lifts no more than 10 inches thick in loose state, with each lift compacted to a non-yielding state with a vibratory mechanical compactor. The compaction and densification of trench fill is critical if it is to support roadways or driveways. Stormwater captured over paved roadways/driveways should be routed into a catch basin equipped with an oil-water separator before being released into the infiltration trenches.

If maintaining groundwater quality is critical, the bottom of trenches should be filled with a minimum 12-inch layer of uncompacted amended soil. The amended soil should contain 40 percent (by volume) of compost, mixed with clean, medium to coarse, sand soil, to achieve an organic content of at least 10% by dry weight. The trenches are then filled with clean 3/4 to 1-1/2 inch washed gravel or crushed rock as recommended above. The dispersion pipes, constructed of 4-inch rigid perforated PVC pipes, should be laid level and completely enclosed by the gravel or crushed rock fill at about 24 inches below the top of trenches. The top of the gravel or crushed rock fill should also be covered with the filter fabric liner. The remaining trenches may then be backfilled with compacted onsite clean sandy soil.

LIMITATIONS

This report has been prepared for the specific application to the subject project for the exclusive use by KNL Construction, Inc., and its associates, representatives, consultants and contractors. We recommend that this report, in its entirety, be included in the project contract documents for the information of prospective contractors for their estimating and bidding purposes and for compliance with the recommendations in this report during construction. The conclusions and interpretations in this report, however, should not be construed as a warranty of the subsurface conditions. The scope of this study does not include services related to construction safety precautions and our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in this report for design considerations. All geotechnical construction work should be monitored by a geotechnical engineer during construction.

Our recommendations and conclusions are based on the geologic and soil conditions encountered in the test borings, and our experience and engineering judgment. The conclusions and recommendations are professional opinions derived in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty, expressed or implied, is made.

The actual subsurface conditions of the site may vary from those encountered by the test borings drilled on the site. The nature and extent of such variations may not become evident until construction starts. If variations appear then, we should be retained to re-

evaluate the recommendations of this report, and to verify or modify them in writing prior to proceeding further with the construction of the proposed development of the site.

CLOSURE

We are pleased to be of service to you on this project. Please feel free to contact us if you have any questions regarding this report or need further consultation.

Yours very truly,
LIU & ASSOCIATES, INC.

J. S. (Julian) Liu, Ph.D., P.E.
Consulting Geotechnical Engineer

JEONG S. LIU
STATE OF WASHINGTON
27589
REGISTERED
PROFESSIONAL ENGINEER
8/11/2014

Six Plates and Appendix attached

APPENDIX

Soil Particle Size Distribution Test Report
Bridle Trails
46xx – 116th Avenue NE
Bellevue, Washington
L&A Jon No. 14-070

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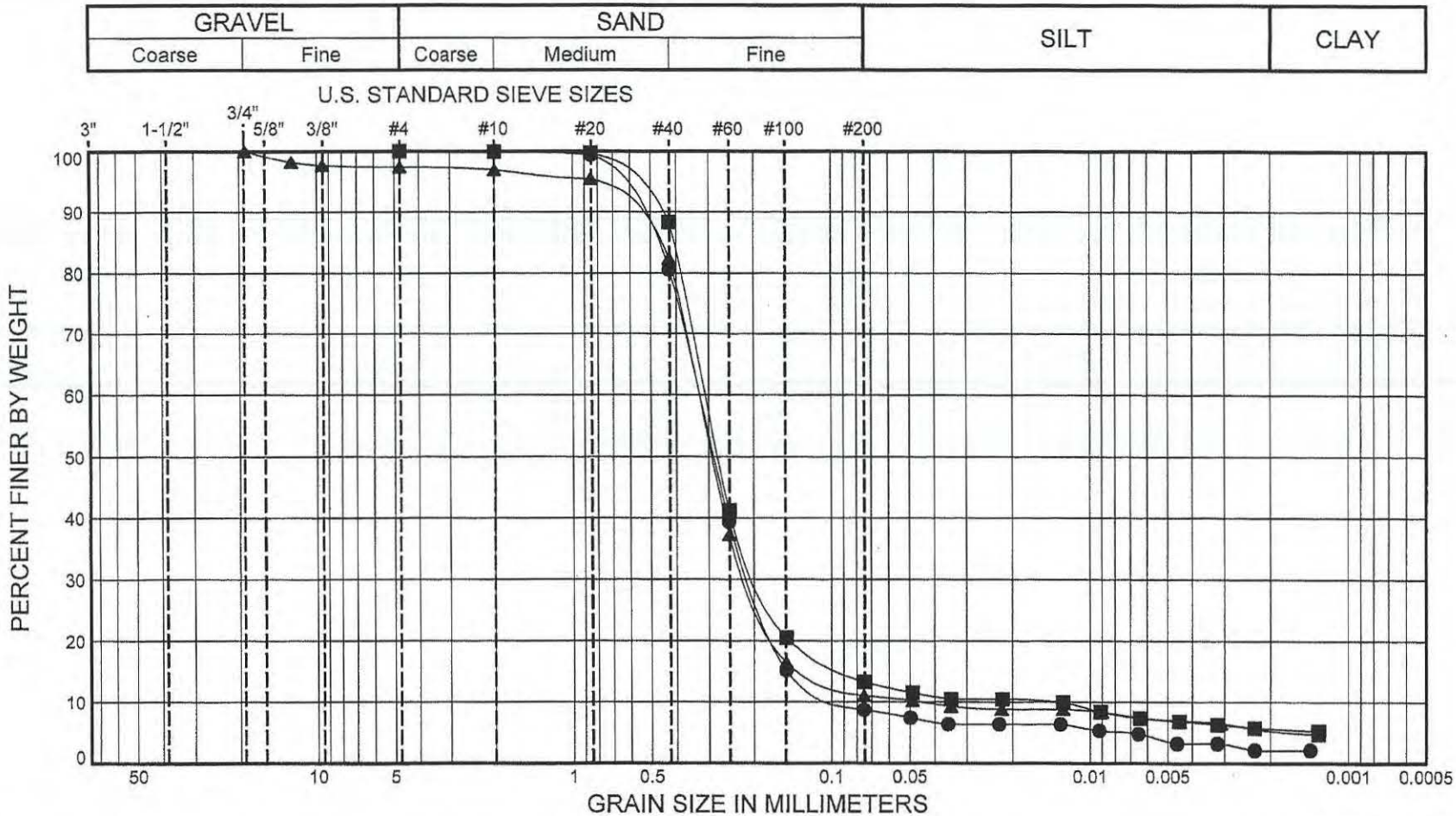


SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	~~TP-1~~ B-1	S-1	7.5 - 9.0	(SP-SM) Olive brown, poorly graded SAND with silt	6				0.0	91.3	8.7
■	~~TP-2~~ B-2	S-2	7.5 - 9.0	(SM) Olive gray, silty SAND	21				0.0	86.8	13.2
▲	~~TP-2~~ B-2	S-3	10.0 - 11.5	(SW-SM) Olive gray, well graded SAND with silt	20				2.6	86.4	11.0

HWA GEOSCIENCES INC.

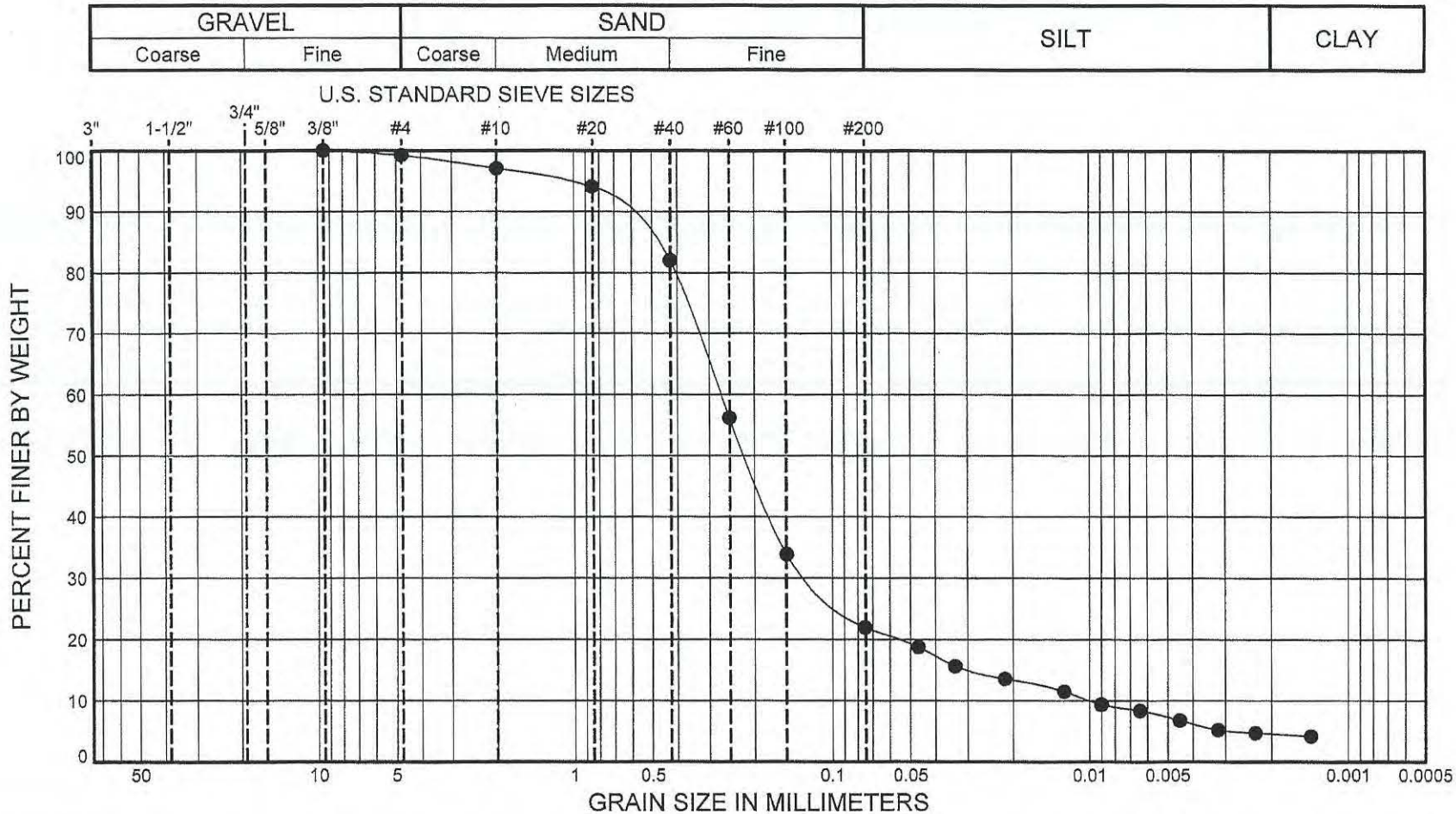
Laboratory Testing for Liu & Associates
Bridle Trail

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PLATE A-1

PROJECT NO.: 2012-025 T5000 FIGURE: 1

HWAGRSZ 2012-025 T5000.GPJ 7/28/14



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	~~TP-3~~ B-3	S-4	7.5 - 9.0	(SM) Dark brown, silty SAND	19				0.8	77.2	22.0

HWA GEOSCIENCES INC.

Laboratory Testing for Liu & Associates
Bridle Trail

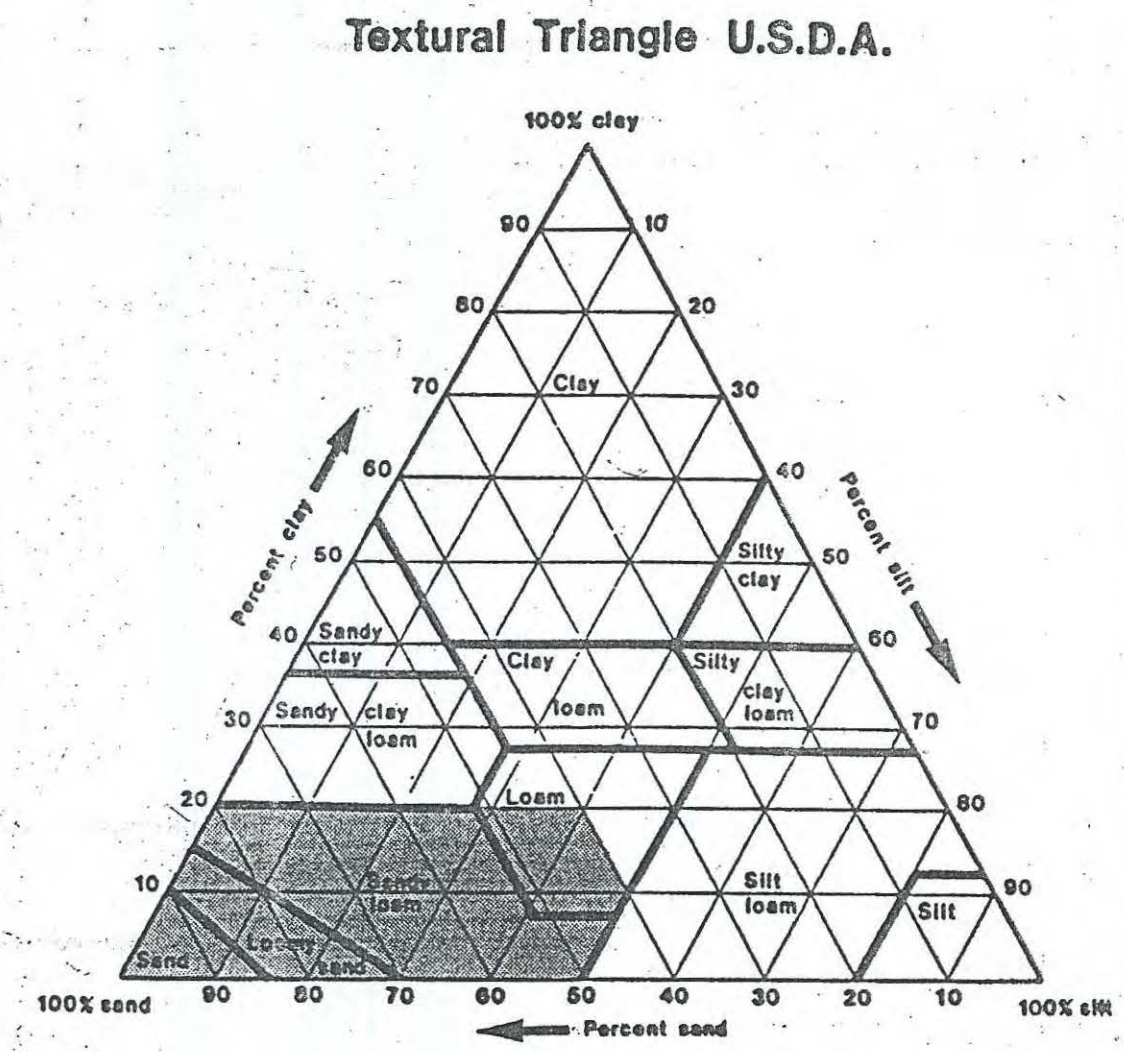
PLATE A-2

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2012-025 T5000 FIGURE: 2

Table 1 – Summary of Sieve Analysis Test Results

Sample ID	Sample Depth (ft)	Classification	MC %	% Gravel	% Sand	% Silt	% Clay	D_{10}
B-1 ~~TP-1~~, S-1	7.5-9	Olive brown, poorly graded SAND with silt (SP-SM)	6	0.0	91.3	6.5	2.2	0.0866
B-2 ~~TP-2~~, S-2	7.5-9	Olive gray, silty SAND (SM)	21	0.0	86.8	7.6	5.6	0.0139
B-2 ~~TP-2~~, S-3	10-11.5	Olive gray, well graded SAND with silt (SW-SM)	20	2.6	86.4	5.7	5.3	0.0460
B-3 ~~TP-3~~, S-4	7.5-9	Dark brown, silty SAND (SM)	19	0.8	77.2	17.4	4.6	0.0100



Shaded area is applicable for design of infiltration BMPs

Figure 3.27 USDA Textural Triangle

Source: U.S. Department of Agriculture

PLATE A-4